Effects of Three Lower Benue Grown Cassava (*Manihot esculanta*) Varieties and Processes on Seven Quality Indices of Fresh *Gari*

Ijabo. O. J., P. K. Igbo

***Abstract*— Three promising cassava varieties, TMS 30572, TMS 90257 and Akpu, were processed into fresh gari and seven of their quality indices studied. The experiment consisted of 3 x 3 two factor randomized Complete Block Design (RCBD) with the three cassava varieties commonly grown in the Lower Benue River Basin as one factor and the other factor the three unit operations of (1) grating (2) dewatering and fermentation and (3) roasting or frying. For the seven indices used methods of determination were moisture content, bulk density and particle size distribution by gravimetric analysis, HCN and swelling capacity by volumetric analysis while water absorbtion capacity was by centrifugal means and pH by meter. Fermentation and dewatering process reduced the HCN content of the fresh peeled and grated tuber to 6.1%, 45.9% and 30.3% in the mash obtained from the three cultivars of TMS 90257, TMS 30572 and Akpu respectively whereas drying finally reduced HCN content of the respective three varieties to 1.404 and 1.62 and 1.38 mg of HCN/100 g of dry gari. Since the level of HCN for the three varieties investigated are below 2.0 mg HCN/100 g of dry gari, the gari obtained from them is safe according to SON (2004) Standard. The gari also met SON (2004} Standard in terms of TTA. The bulk densities are 0.6133 ± 0.0053 > 0.5376 ± 0.0004 > 0.5248 ± 0.0047 for TMS 30572, Akpu and TMS 90257 respectively. As for the individuals the values of swelling capacity for TMS 30572 is 400.00 ± 8.89 > Akpu is 379.67 ± 3.21 > TMS 90257 is 314.67 ± 7.09 when tested with ANOVA and means separated. Water absorbing capacity is the same for the three varieties, which is 4.74 ± 0.28. Although the gari fall into the coarse group, most of the grain sizes fall in the range of 1.00 to 1.10 mm. Gari from these three cassava varieties grown in the Lower Benue River Basin meet SON (2004) Standard and should be encouraged except that the grain size should be reduced.**

Index Terms — Gari, varieties, HCN, processes and quality indices.

I. INTRODUCTION

For the last five decades Nigeria, Brazil, Thailand and Indonesia have been swapping positions as the world top producer of cassava, *Manihot sp*. In 2012 Nigeria produced 54, 000, 000 MT of cassava out of the world figure of 269, 125, 963 MT placing her as the current number one world producer, a position she has held consecutively since 1991[1].

The same source indicated that within the country cassava production in MT top all the other crops produced by the country in the same year. This means that Nigeria is an icon in cassava production.

Cassava can be processed and served as flour (*alibo*), fermented fufu (*akpu*), or in a granular form called *gari*. Furthermore, *gari* could be served as hot dough called *eba* with soup or soaked and taken with roasted groundnut, coconut, smoked fish or meat, palm kernel or such other snacks. There is an ongoing research in Nigeria to increase the level of substitution of cassava flour for wheat in baking and confectionary industry [2]

Nigeria being an icon in cassava production means that she should be a reservoir of knowledge on cassava by variety in the same manner the temperate countries have on apple and potato. Such knowledge would enhance identification of improved and safe varieties needed to ensure food security. If food security is defined as guaranteed availability of food in sufficient quantity and quality over time and space, it can be said that Nigeria has taken a positive step in the area of ensuring adequate quantity by continuous release of high yielding improved cassava varieties progressively from those yielding 9.9 to 43 t/ha [3]

In the area of quality assurance, it is noteworthy that Nigerian Industrial Standard (NIS) for gari by Standard Organization of Nigeria (SON) has become a global reference material. According to Director of SON's speech on 2015 world standard day (14th October, 2015), both ISO and Codex Almaterius have adopted the NIS Standard for gari. It took Nigeria a number of studies to arrive at and properly domesticate this standard. In one of such studies [4] Ijabo reported that a high percentage of *gari* in Benue state of Nigeria neither meet customer quality nor Standard Organization of Nigeria (SON) standard when moisture content, particle size, packaging and dockage were used as quality indices. The study which is about 2½ decades ago omitted a very critical quality factor like the hydrogen cyanide (HCN) content. Thus other investigators [5] have identified HCN as a key quality factor and consequently quantified the HCN in different varieties of cassava and the effects of processing techniques in the reduction of total HCN to below the safe limit of 20 mg/kg [6].

In order to make information in cassava utilization comprehensive there should be continuous research and development. Apart from cassava tuber yield per hectare, there are investigations into *gari* yield from a given quantity of fresh cassava tubers. In one of such studies Amoah *et al.* [7] reported *gari* recovery rate of 23%. Therefore, the aim of this study is to carry out a comprehensive determination of the effects of processing unit operations and cassava varieties grown in the Lower Benue River Basin in Nigeria on both the safety and physical properties of *gari* produced there-from.

II. MATERIALS AND METHODS

A. Materials

The cassava varieties used for this research work were two promising improved varieties, (TMS 90257 and TMS 30572) and one local variety called *akpu* obtained

from Benue Agricultural and Rural Development Authority (BNARDA) farm at Ushongo Local Government Area, Benue State, Nigeria. The tubers were harvested at a physiologically mature age of 12 months.

B. Sample Preparation

The tubers were sorted by visual inspection and the intact good ones were processed using the nine unit operations cited in SON [6] to include peeling, washing and grating of tubers followed by fermentation, pressing, breaking of the cake, sifting, partial dehydration of what passed through the sieve and then the final drying. The tubers were peeled manually with a knife within 12 hours after harvest. Washed tubers were grated using a mechanical grater after which samples were collected immediately for the determination of initial physico-chemical properties of Hydrogen cyanide (HCN) content, moisture content (MC) and pH.

The water containing starch was squeezed out of the remaining grated mash in a batch of experiment using a hydraulic jack and wooden planks. The set-up was held under the jack load for three days to ferment. At the end of fermentation/dewatering period samples were taken for the second analysis. The remaining cake was pulverized, sieved and the under-size fried until the product becomes granular and crispy. The frying was done using an iron pan and stirring was facilitated by using a neatly cut piece of calabash. After frying dry, the granular gari was spread to cool for about six hours then sieved and samples taken for analysis with the remainder identified and packaged in units of 1 kg bags inside hessian bags for storage. The tests carried out on the fresh gari include the determination of seven quality indices – (1) HCN content, (2) pH, (3) moisture content (4)The swelling capacity in bulk sample (that is before sieve analysis), (5) Bulk density (6) water adsorption capacity and (7) Particle size distribution.

C. Physico-chemical Analysis

1) Moisture content

Moisture content was determined according to SON Standard, NIS 181: 2005 [6] by oven drying five (5 g) of sample in an oven at 100⁰ C - 105⁰ C for four hours with three replications. However, the moisture content was expressed on dry basis, MC % (db), as given by equation 1.

$$\% \, MC \, (wb) = \frac{Weight \, of \, wet \, sample - weight \, of \, dry \, sample}{Weight \, of \, dry \, sample} x100 \quad \ldots.. \, 1$$

2) Quantitative determination of HCN

The quantitative determination of HCN was done using the alkaline titration method as described by Ogiehor and Ikenebomeh [8]. Equation 2 gives the expression for calculating the HCN.

1 ml of 0.02 N $AgNO_3$ = 1.08 mg HCN …….. 2

3) Determination of Bulk Density, ρ_b

In line with [9, 10] about 50 g of the sample was weighed in a pre-weighed 250 ml graduated cylinder and tapped gently for 10 to 15 times and the final weight taken. Equation 3 is the expression for the bulk density in g/c³.

$$\rho_b = \frac{Final \, mass \, of \, filled \, cylinder, \; g - Mass \, of \, empty \, cylider, \; g}{Graduation \, reading \, on \, the \, cylindr, \; cl} \quad \ldots \, 3$$

4) Determination of particle size distribution

Percentage particle size distribution was done according to ASAE S319.3 JUL99 [11]. About 400 g of *gari* sample was shaken by a mechanical agitator for 30 minutes through 0.15 – 2.00 mm sieve on a laboratory impact sieve shaker. The particles that were left on each sieve after sieving were weighed and divided by the amount of charge supplied to the sieves and multiply by 100.

5) Determination of water absorption capacity

Using the definition of [12] and [13] the water holding capacity is the weight of water that is held by one gram of the dry material (in this study, gari) under the following described condition of soaking and centrifugation. About one gram of the sample was weighed in a 25 ml capacity plastic centrifuge and 10 ml of distilled water was added and mixed thoroughly by shaking. The sample was allowed to stand at room temperature for 30 minutes. The supernatant was discarded and the tubes were allowed to drain for 30 minutes after which the pellet was weighed. The difference in weight between the wet and dry gari was taken as the amount of water held by the gari.

$$W_{ac} = W_f - W_i \quad \ldots\ldots\ldots \, 4$$

Where,

Wac = Water absorption capacity, g of water/g of dry *gari*

Wf = Final weight of gari pellet, g

6) Determination of swelling capacity

The swelling capacity was determined according to the procedure described by [9, 10]. In this study about 10 g of the gari sample was poured into a graduated 100 ml cylinder and the bulk volume was noted. Then the cylinder was filled with water to 100 ml level as the bench mark and allowed to stand for 24 hours.

III. RESULTS AND DISCUSSIONS

A. Effects of variety and unit operations on two chemical properties of fresh gari

The two chemical properties of fresh gari are HCN content and pH**.** The 18 data points (2 parameters by 3 operations by 3 replications = 18) of HCN content and pH obtained for the three cassava varieties during various processes were subjected to analysis of variance using spss Software and the result is given in Table 1. The results show that variety, unit operation and their interactions have significant effects on HCN content and pH of fresh gari obtained from the three cassava varieties at p = 0.95. The means of the values for the parameters were further subjected to separation of means using Duncan's Multiple Range Test (DMRT) [14] and the results are as in Table 2.

Table 1: Two-factor ANOVA for effects of cassava varieties and processes on four properties of fresh gari

S/NO	Parameter	Source of variation	SS	df	MS	F	P-Value	$F_{critical}$	Remarks
1	HCN	Varieties	244.2	2	122.1	211.8	3.12E-13	3.555	*
		Processes	244.2	2	222.1	385.1	1.69E-15	3.555	*
		Interactions	484.6	4	121.2	210.0	7.71E-15	2.928	*
		Within	10.383	18	0.5768				
		Total	1183.5	26					
2	pH	Varieties	0.1879	2	0.0940	528.6	1.03E-16	3.555	*
		Processes	11.06	2	5.532	31120	1.41E-32	3.555	*
		Interactions	0.4206	4	0.1051	591.5	7.93E-19	2.928	*
		Within	0.0032	18	0.0002				
		Total	11.67	26					
3	Moisture Content	Varieties	21.21	2	10.60	44.08	1.16E-07	3.555	*
		Processes	13220	2	6608	2747	4.34E-32	3.555	*
		Interactions	59.38	4	14.85	61.71	2.91E-10	2.928	*
		Within	4.331	18	0.2406				
		Total	13300	26					
4	Swelling capacity	Varieties	21492.7	2	5373	13.73	1.781	2.6896	*
		Particle size	5971.9	4	2986	7.63	0.0021	3.3158	*
		Interactions	7074.6	8	881	2.25	0.0513	2.2661	*
		Within	11737.1	30	391				
		Total	46249.3	44					

The mean (mean ± SD) total hydrogen cyanide content (mg/100g) of the three cassava varieties used were 23.112 ±2.147, 4.572 ±0.272 and 3.528±0.125 for *TMS* 90257, Akpu and TMS *30572* cultivars respectively. Based on the total cyanide level in each cultivar and the classification of Coursey [15], *TMS* 30572 and *Akpu* can be classified as low cyanide (sweet) cassava since their respective total cyanide content are less than 5 mg HCN/100g fresh weight while TMS *90257* can be classified as a high cyanide (bitter) cassava since its total cyanide level is above 5 mg/100g fresh weight. The relative advantage of *TMS 30572 and Akpu* (low cyanide cultivars) over the *TMS 90257* (high cyanide cultivar) is that they would require minimal amount of processing time and can be boiled, roasted, grated and made into different dishes straight from the field, whereas the *TMS 90257* must be given elaborate processing to reduce the HCN content before consumption. There is controversy over the classification of TMS 30572 grown in Owo, Ondo State Nigeria and the one in this study. Whereas [10] classified this variety as bitter the same variety grown in Ushongo, Benue state in this paper is classified as sweet. Although both locations are in Nigeria but in different ecological zones, it is doubtful if edaphic factors can introduce such a change as to warrant controversy.

Taking the HCN values of the peeled fresh roots at grating as bench mark, it would be necessary to consider the contributions by the other two unit operations of (1) fermentation and dewatering and (2) frying. These two processes reduced the HCN content of the fresh peeled and grated tuber to 6.1%, 45.9% and 30.3% in the mash obtained from the three varieties of TMS 90257, TMS 30572 and *Akpu* respectively. The final HCN content of the three cultivars are 1.38, 1.404 and 1.62 mg of HCN/100 g of dry *gari* for *Akpu*, TMS 90257 and TMS 30572 respectively. Since the level of HCN for the three cultivars investigated are below 2.0 mg HCN/100 g of dry gari, the gari obtained from them is safe according to SON [6] (2004) Standard. Therefore, for the cassava cultivars studied the gari produced from them, following SON [6] (2004) Standard, are safe in terms of HCN content.

The pH of all the gari range from 4.6 to 5.8, so all the gari samples can be considered to be acidic. These values are in the same range with [10, 9]. The acidity of fermented cassava roots and its products has been found to be caused by the synthesis of lactates, acetates and some volatile organic acids [16]. The acid contributes to the desirable sourness of gari and it is also an indication of the duration and effectiveness of the fermentation step in gari processing. The total titratable acidity (TTA) expressed as percentage lactic acid of *gari* samples from similar cassava varieties by [10] were between 0.54 ± 0.01 and 0.84 ± 0.03. These values are in agreement with NIS recommendation of less than 1% m/m of TTA for *gari* samples. By extension the *gari* in this study have met SON [6] Standard in the aspect of acidity

Table 2: Mean*HCN content, moisture content and pH of fresh gari as affected by cassava variety and process

Parameter	Process	Cassava variety			Critical value
		TMS 90257	TMS 30572	*AKPU*	
HCN, mg HCN/ 100 g dry gari	Grating	23.112a	3.528c	4.572e	
	Fermenting & Dewatering	2.268b	1.872d	2.376f	2.0**
	Frying	1.404b	1.62d	1.386g	
Moisture content, %, dry basis	Grating	61.7333h	63.3867l	66.177o	
	Fermenting & Dewatering	46.7798j	50.519m	45.348p	7.0**
	Frying	11.0206k	11.917n	9.687q	
pH	Grating	6.0567r	4.4767s	4.623t	
	Fermenting & Dewatering	5.9500u	4.7767v	4.810w	3.5 to 4.5***
	Frying	5.8767x	4.2133y	4.840z	

Means followed by the same letter on the same column and row are not significantly different from each other at p= 0.95 according to DMRT.
** Source: [6] *** Source: Ukpabi and Ndimele 1990

B. Effects of cassava varieties and unit operations on five physical properties of fresh gari

1) Moisture Content

Using peeled fresh tubers as reference point all the two processes of (1) dewatering and leaving to ferment plus (2) frying affect both final moisture content and contribute to moisture content reduction. Following the same line of argument as for the HCN in section IIIA, the moisture content (%, db) reduction pattern by the processes across the varieties, after ANOVA and separation of means, are all significantly different from each other as in Tables 1 and 2.The particular case for TMS 90257, is as follows: dewatering and fermentation effected a moisture content reduction of 24.2% whereas frying gave a further reduction of 58.0% bringing the final moisture content to 11.0%. Similarly, for TMS 30572, dewatering and fermentation effected a moisture content reduction of 20.3% while frying gave a further reduction of 81.2% bringing the final moisture content to 11.9%. For the third cultivar, *Akpu*, dewatering and fermentation effected a moisture content reduction of 31.4% while frying gave a further reduction of 85.3% bringing the final moisture content to 9.7%.
Moisture removal is a function of some factors such as temperature, variety, time, humidity, pressure applied etc. [18]. For all the three cassava varieties investigated it can be deduced that frying contributes more to moisture reduction than dewatering by pressing. This may be explained in terms of the ability of the dry heat used in frying to remove more free and absorbed moisture in the mash by evaporation than the combination of pressure from pressing and chemical reaction from fermentation as days pass by. The respective final moisture contents of the gari from the three cultivars are 11.02%, 11.92% and 9.69% for TMS 90257, TMS 30572 *Akpu* respectively on dry basis. When these values are converted to wet basis in order to compare with grains the moisture content of the gari samples are low but by [6] Standard for gari they are 9.9%, 10.6% and 8.8%, which are still higher than 7.0% wet basis. The implication is that gari produced from these cassava varieties are, in terms of moisture content, lower than and not up to [6]) Standard. Therefore, barring environmental conditions, the frying process needs to be adjusted to higher temperatures or longer time or both to ensure further drying. However, if the present time-temperature is maintained, then when it comes to packaging for storage these gari would have shorter shelf-life otherwise a less moisture permeable packaging material would be needed to keep the gari in the same environment for the length of time specified by [6]

2) Bulk density, swelling capacity and water absorption capacity

Table 3 shows that cassava variety has significant effect on the two out of the three physical properties; namely, bulk density and swelling capacity at $\alpha=0.05$ using Microsoft Excel Statistical package. The result of separation of means of these two physical properties using Duncan's Multiple Range Test (DMRT) is corroborated by the error bar diagrams in figure 1. In the particular case of bulk densities, $0.6133 \pm 0.0053 > 0.5376 \pm 0.0004 > 0.5248 \pm 0.0047$ for TMS 30572, Akpu and TMS 90257 respectively. The meaning is that in a market situation where gari is sold by weight the gari from TMS 30572 cassava variety will sell at a higher price for a given volume, e.g. *mudu*, which would be of a relative advantage.
Although [6] did include bulk density as a quality index for gari [9] suggested that a good *gari* should have bulk density within the range of 0.568 to 0.908 g/cm^3. Accordingly only gari made from TMS 30572 with bulk density of 0.613 g/cm^3 is good while those of TMS 90257 and *Akpu* fall below the range. Initial toasting rate of the mash during frying affects the size of the lumps formed which in turn affects the bulk density. Experience of the investigators indicates that the lower the initial toasting rate the bigger the lumps. Therefore, the toasting rates should be bench-marked and adjusted accordingly to obtain good gari based on bulk density. On the other hand perhaps tubers from TMS 90257 and Akpu in the same chronological age with TMS 30572 might have developed faster than TMS 30572 physiologically. In which case the breeders in collaboration with the processors might need to investigate the chronological age at which the disadvantaged varieties can best be harvested.

Table 3: Combined Single-factor ANOVA for effect of cassava variety on three physical properties on fresh gari

S/No	Physical property	Source of variation	SS	df	MS	F	P-value	Remarks
1	Bulk density	Between Groups	.014	2	.007	370.681	.000	*Significant
		Within Groups	.000	6	.000			
		Total	.014	8				
2	Swelling capacity	Between Groups	13497.556	2	6748.778	144.962	.000	*Significant
		Within Groups	279.333	6	46.556			
		Total	13776.889	8				
3	Water absorbing capacity	Between Groups	.681	2	.340	3.592	.094	Not Significant
		Within Groups	.568	6	.095			
		Total	1.249	8				

*Variety has significant effect at α= 0.05

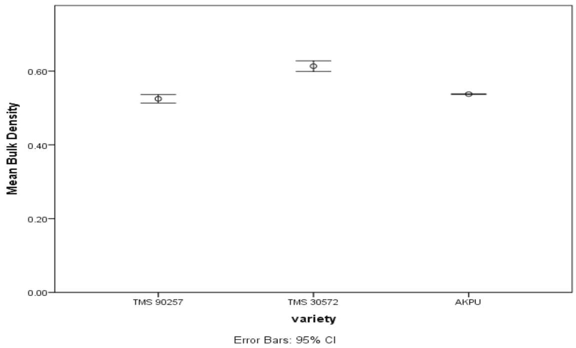


Figure 1: Error bar of bulk density of three cassava varieties grown in the Benue River Basin

According to [18], a good quality gari should have 300% to 500% range of swelling capacity. The starch granule in the gari fall in this range of 300 to 500% and when it absorbs water it swell. As for the individuals the values for TMS 30572 400.00 ± 8.89 > Akpu 379.67 ± 3.21 > TMS 90257 314.67 ± 7.09 and when tested with ANOVA and separated for means. This again shows the significant difference between means as in figure 2. This is the same order that the bulk densities vary.

In the case of ANOVA and separation of means of water absorbing capacity they are the same for the three varieties and the mean water absorbing capacity is 4.74 ± 0.28 is returned for all. The error bar corroborates this information as shown in figure 3.

3) Effects of variation of particle size and variety on %mass retained

Fig 4 shows the variation of particle size distribution of freshly prepared gari with cassava variety. It reveals the % mass retained of gari in the respective sieves of sizes (2.0, 1.0, 0.5, 0.425, 0.350, 0.300, 0.250, 0.212, and 0.15 mm). It was observed that sieve size 1.00 mm had the highest %mass retained of gari from TMS 90257, TMS 30572 and Akpu of 40.63%, 34.52% and 41.94%. Based on sieve size 1.00 mm, TMS 30572 was less coarse with the lowest 34.52 % mass retained and Akpu the coarsest with the highest % mass retained. ANOVA shows that there was a significant difference at α=0.05 in the particle size of the gari samples. Therefore, gari should have particle size of ≤ 1.0mm. Particle size >1.00mm would be grinded and sieved to the desired size or the gari could be sold at a cheaper rate.

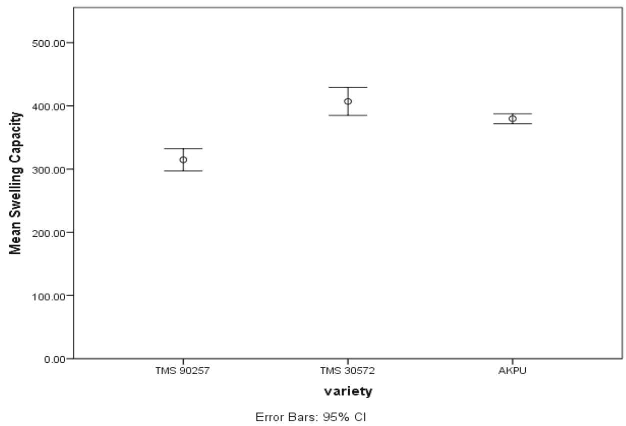


Figure 2: Error bar of swelling capacity of gari from three cassava varieties grown in the Benue River Basin.

Figure 5 shows the variation of particle size of gari with cassava variety and cumulative mass (%less than size indicated). The graph (a logarithmic graph) shows that at d50 (particle diameter at 50% probability; average particle size), TMS 90275 is at particle diameter 1.00mm and TMS 30572 and Akpu fall in the range of 1.0-1.1mm. This indicates that due to the same method of grating and sieve used for the three varieties they all fall in the range of particle diameter 1.0-1.1mm.

However, if the particle sizes are viewed in terms of the five classes of gari, according to gari classification, then all the gari fall within the coarse class. The coarse class says, "This is gari of which no less than 80% of the weight shall pass easily through a sieve with aperture 1.4 mm (Not determined) but of which less than 80% of the weight shall pass through a sieve with the aperture 1 mm."

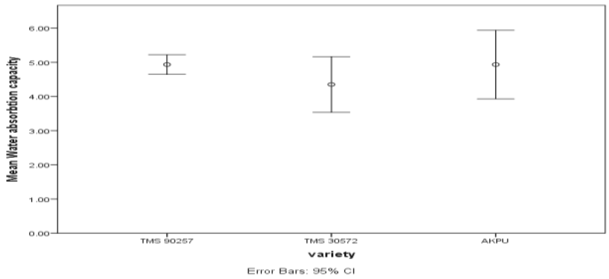
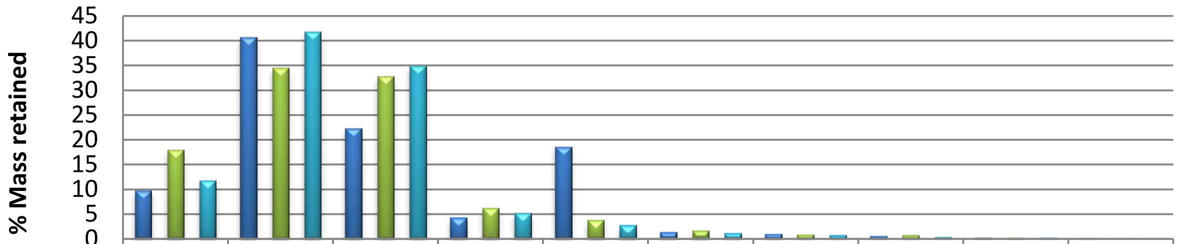


Figure 3: Error bar of water absorption capacity of gari from three cassava varieties grown in the Benue River Basin



	2.0mm	1.0mm	0.50mm	0.425mm	0.355mm	0.30mm	0.250mm	0.212mm	0.150mm	Pan
TMS 900257	9.7212	40.6323	22.2587	4.296	18.542	1.356	0.9943	0.5962	0.242	0.1587
TMS 30572	17.9683	34.5212	32.762	6.2027	3.7287	1.6543	0.8757	0.7043	0.2923	0.1228
AKPU	11.7	41.7427	34.9298	5.1757	2.752	1.1128	0.721	0.372	0.2303	0.1253

Figure 4: Particle size distribution of fresh gari as affected by cassava variety.

REFERENCES

[1] Food and Agricultural Organization 2015. Cassava production by country. faostat3. Fao.org/browse/ Accessed on 27th January 2016.

[2] Odum, Fabian. 2015. Cassava Flour Inclusion Policy: Looking At The Bottom Line. The Guardian Newspaper, Wednesday 4th November 2015.

[3] Adeloye, Layi. 2011. IITA announces discovery of new cassava varieties in Nigeria. Nigerian Best Forum. http://www.nigerianbestforum.com/index.php?topic=105646.0 Accessed on 4th November 2015

[4] Ijabo, O. J. 1990. Evaluation of gari in Makurdi according to SON Standard. A paper presented at the 14th annual conference of Nigeria Society of Agricultural Engineers, held at the University of Agriculture, Makurdi from .. to … September, 1990. (Unpublished)

[5] Akoroda, M.O. and A.E. Ikpi. 1992. The adoption of improved cassava varieties and their potential as livestock feed in Southwestern Nigeria. In Hahn, S. K., Len Reynolds, G. N. Egbunike (Eds). Cassava as Livestock Feed in Africa_ Proceedings of the IITA_ILCA_University Google Books.html. Or http://www.fao.org/wairdocs/ilri/x5458e/x5458e0c.htm. Accessed on 4th November 2015.

[6] Standard Organization of Nigeria (SON). 2004. Nigerian Industrial Standard: NIS 181: 2005). Standard for gari. Standard Organization of Nigeria, Plot 1687, Lome street, Wuse Zone 7, Abuja, Nigeria. Pp 15.

[7] Amoah, R.S., L.K. Sam-Amoah, C. Adu Boahen and F. Duah, 2010. Estimation of the Material Losses and Gari Recovery Rate during the Processing of Varieties and Ages of Cassava into Gari. *Asian Journal of Agricultural Research, 4: 71-79.*

[8] Ogiehor, I. S. and Ikenebomeh, M. J. 2006. The effects of different packaging materials on the shelf stability of gari. African J of Biotech 5(23): 2412 - 2416

[9] Ukpabi, U. J. and C. Ndimele. 1990. Evaluation of the quality of gari produced in Imo State. Nig. Food Journal 8: 105 -109.

[10] Komolafe E. A. and J. O. Arawande. 2010. Quality characteristics of gari produced in some selected cassava processing centres in Owo, Ondo state, Nigeria. Transcampus. Journal of research in national development Vol. 8 No 1, June 2010. http://www.transcampus.org/JORINDV8Jun2010/JournalsV8NO1Jun201048.html. Accessed on 4th November 2015.

[11] Americaan Society of Agricultural and Biological Engineers (ASABE). 2009. ASABE Standards, ANSI/ASAE S319.3 FEB03. Method of determining and expressing fineness of feed materials by sieving. St Joseph MI 49085-9659.

[12} Eastwood, M. A.; Robertson J. A. Brydon, W. G and MacDonald D. 1983. Measurement of water holding capacity and their faecal bulking in man. Br J Nutition 50: 539-547

[13]. Makanjuola, Olakunle M.; Akinwale S. Ogunmodede, John O. Makanjuola, and Samuel O. Awonorin. 2012. Comparative Study on Quality Attributes of Gari Obtained from Some Processing Centres in South West, Nigeria. Advance Journal of Food Science and Technology 4(3): 135-140, 2012 ISSN: 2042-4876. http://maxwellsci.com/print/ajfst/v4-135-140.pdf. Accessed on 4th November 2015.

[14] Duncan, D. B. (1955). Multiple Ranges and Multiple F-tests. Biometrics Vol. II, 1-42

[15] Coursey, D. G. (1973) Cassava as Food: Toxicity and Technology in Chronic Cassava Toxicity (Nestle, B. L. and Macintyre, R. Eds.) IDRC Ottawa, Canada. P 27-35.

[16] Oyewole, O. R. and S. A. Odunfa. 1992. Extracellularenzyme activities during cassava fermentation to fufu production. World Journal of Microbiology Biotechnology 8: 71-72.

[17] Irtwange. S.V.and Achimba.O. (2009). Effect of the duration of fermentation on the quality of gari.Department of Agricultural and Environmental Engineering, University of Agriculture, Makurdi. Current Research Journal of Biological Science 1(3):150-154

[18] Ingram, J. S. 1975. Standard specification and quality requirement for processing cassava Reports G102 Tropical Products Institute, London

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